2.0 DESCRIPTION OF CHEMICAL TREATMENT PILOT UNITS, METHODS AND MATERIALS

The CTSS treatment technology is a conventional chemically assisted sedimentation water treatment process utilizing coagulation, flocculation, clarification, and rapid granular media filtration process units.

2.1 PROCESS DESCRIPTION

As shown schematically in **FIGURE 1.2**, raw water enters the system in the coagulation tank. Chemical coagulant and pH adjusting agents can be added into or prior to this tank to destabilize suspended solids and colloidal matter. The dispersion of these process chemicals could be achieved either by an inline static mixer or by a mechanical mixer located in the coagulation tank.

There were two coagulant tanks of different volume available in the pilot units, in which the hydraulic detention times were about 2 minutes and 20 minutes, respectively, at a flow rate of 10 gallons per minute. The tanks could be utilized either in series or singularly. Both tanks were equipped with mechanical mixers to enhance the dispersion of the added process chemical(s).

The aggregation of flocs continues as water enters the flocculation process using two tanks in series. The two identical flocculation tanks were equipped with variable speed mechanical mixers. The relatively low energy input agitation of the pretreated water provides ideal conditions for the formation of larger size aggregates. This process was typically further augmented by the dosage of a coagulant aid (polymer) into either of the flocculation cells. The hydraulic detention time in each flocculator tank is 20 minutes (at a feed flow rate of 10 gpm).

The separation of fully formed flocs takes place in the downstream clarifier unit. The 6-square foot plan area clarifier is equipped with 28 inclined settling plates with a total projected surface area of 28 ft^2. Each plate was one-foot deep by two-feet wide and inclined 60 degrees from vertical. Clarifier surface loading rates were investigated in the 0.14 gpm/sq.ft. to 0.71 gpm/sq.ft. range of projected area. The clarified water exited the unit through a collector trough or weir. By the discharge of calculated amount of pretreated water from the clarifier influent, the clarifier surface loading rate and the hydraulic detention time in the upstream treatment units could be maintained independently. Underdrain residual solids from the clarifier were periodically discharged to the residual solids holding tank/pond. A portion of the solids could be recycled to either of the upstream tanks, if desired.

The final treatment process was rapid granular filtration achieved in eight inches diameter filter columns. Several filter media were tested, including 1) anthracite, 2) expanded shale, 3) sand, 4) granular activated carbon, and 5) polystyrene. Declining rate filtration and constant-rate filtration operation modes were primarily tested. Hydraulic filter loadings were investigated in the range of 4 gpm/sq.ft. to 10 gpm/sq.ft. In-ground steel tanks stored water for filtrate use during filter backwashing. Both filtrate and air scour was used for the periodic backwash of the filter columns.

FIGURES 2.1 through **FIGURE 2.3** provide various photographs of the CTSS pilot facility including pictures inside the treatment trailers showing the process tanks and outside shots of the filter columns and the solids retention storage tanks.

There are essentially two sources of residuals in the treatment process, (1) clarifier solids discharge and (2) filter backwash. These residual lines are connected to a collector header, which discharges to either one of two holding tanks. The 2,500-gallon tanks are used alternately to receive residuals depending on the type of coagulant in use (*i.e.*, aluminum or iron salt).

2.1.1 Process Chemicals

The two primary functions of coagulant chemicals are particle destabilization and strengthening of flocs to reduce floc breakup. The coagulant must form highly insoluble compounds or be strongly adsorbed on particulate surfaces, thus minimizing the concentration of soluble residuals that might pass through the treatment plant.

Selection of the type and dose of coagulant depends on the characteristics of the coagulant, the particles, and the water quality. Because of the complex nature of coagulation, each coagulation problem must be solved empirically. Due to the negative surface charge of most naturally occurring particles, the most effective coagulants are compounds that have a positive charge of high valence. The two principal inorganic coagulants used in water treatment are salts of aluminum and ferric ions. Lime is also used for coagulation when high pH values are desired.

The CTSS pilot tests included the use of water treatment grade lime, ferric-chloride, alum and Cytec anionic polymers A-1849 and A-130. The ferric-sulfate used for the project was donated by KEMIRON and General Chemicals provided the alum.

2.1.2 Coagulation, Flocculation

"Coagulation" is a process of chemically altering colloids so that they will be able to approach each other and form larger particles. "*Flocculation"* is the physical process of bringing the coagulant particles into contact to promote floc formation.

Fine particles (usually less than 10 micron), do not settle out of suspension by settling alone in an economical time frame, requiring the production of larger size aggregates. The aggregation of particulate matter, which allows cost-effective separation, is a two-step sequential process. In the initial step, the interparticle forces responsible for the stability of the particulates are reduced or eliminated by addition of suitable chemicals. Subsequently, particulate collisions occur due to transport by molecular motion or mechanical mixing.

There are four basic mechanisms of *destabilization*:

1. Compression of the electrical double layer;
2. Electrostatic attraction;
3. Interparticle bridging; and
4. Sweep floc or enmeshment.

Double Layer Compression. Increasing the ionic strength compresses the double layer causing a decrease in its thickness. When the zeta potential is $< \pm 20$ mV, rapid coagulation is likely to occur.

Electrostatic Attraction. Many particulates in waters have surface charges dependent on the solution pH and can exhibit both positive and negative surface charges. The pH corresponding to a surface charge of zero is defined as the *zero point of charge (ZPC)*. Above, the ZPC the surface charge is negative; below, it is positive.

Interparticle Bridging. Long chain polymers carrying negative charges can form bridges between particulates, thus destabilizing the suspension.

Enmeshment (Sweep Floc). Some soluble cations such as aluminum, iron or magnesium hydrolize and form an insoluble precipitate, thereby minimizing the concentration of ions added to the water.

The three principal modes of particulate transport are:

1. *'Brownian'* motion (perikinetic flocculation);
2. Differential movement due to fluid shear (orthokinetic flocculation); and
3. Differential movement from particulate sedimentation.

The '*Brownian'* motion affects the movement of colloidal particles (5 nm to 1 μm) only.

Fluid flow in mechanically mixed flocculation system is rarely laminar. Under turbulent flow conditions, the velocity gradient is not well defined and can vary locally in the flocculation reactor. When flow conditions are turbulent, floc breakup cannot be neglected. Small particles are sheared from larger aggregates when the local shear stress exceeds the internal binding forces of the aggregate. The principal mechanisms of aggregate or floc breakup are surface erosion.

The velocity of particles of similar densities settling in a water column is proportional to the size squared. For suspensions containing a wide range of particle size, differential sedimentation can be a significant transport mechanism.

2.1.3 <u>Clarification</u>

Sedimentation of aqueous suspensions can be accelerated by increasing particle size or by decreasing the distance a particle must fall prior to removal. The first is achieved by coagulation and flocculation prior to sedimentation. The second can be achieved by making the settling distance of floc aggregates as small as possible or practical. The design of shallow settling basins is limited by practical aspects. The application of inclined parallel plates in either newly designed or existing basins is an economical way of enhancing clarification efficiency. The parallel plates reduce the vertical settling distance to a few inches and allow the settled sludge to flow in a countercurrent direction from the suspension flow passing upward through the plate. Thus, solids drop to the bottom of the clarifier and are removed by conventional removal techniques.

The range of projected area overflow rates used during test was from 0.14 to 0.71 gallons per square feet per minute. Underdrain solids were pumped at a regular basis to a residual solids storage tank. The underdrain pumping rate was set at 0.6 gallons per minute during pilot unit operations.

2.1.4 <u>Filtration</u>

Filtration through granular media is a widely used phase separation process. The type and physical characteristics of the media has an effect on filter operation and performance, including 1) approach velocity, 2) headloss, 3) surface or depth filtration, and 4) effluent water quality.

The two basic mechanisms of granular filtration are the transport and attachment of solids. Under most conditions, transport is not rate limiting. Destabilization of suspended particles is essential for the attachment process to occur. Depending on filter design, particulate materials either accumulate on the surface of the medium or are collected through its depth.

Optimum filter performance occurs when the time to reach a limiting headloss is reached at the same moment that the effluent quality exceeds the specified standards. Granular filters need backwashing before reaching any of the limiting conditions (*i.e.*, headloss or breakthrough). Filtration assisted by air scour is typically used for filter backwash.

For the CTSS tests, numerous filtration media were used including shale, anthracite, sand, polystyrene beads and activated carbon. These media were installed in eight-inch diameter, 10-foot tall plexiglass filter columns. Filtration hydraulic loading testing rates ranging from 5 to 10 gallons per minute per square feet of filter media were tested. A combination of air scouring and backwashing using collected filtered water was routinely used to clear the filters. Air scour and water backwash rates were adjusted to each filter columns containing different media to provide approximately 30 percent fluidization of the filter bed. Filter media characteristics used during the CTSS screening phase are reported in **TABLE 2.1**.

A total of six filter configurations were tested. Five of these filters were operated in the conventional downflow mode. Filter 1C, utilizing polystyrene filter media, was operated in the upflow mode. Filter media selected for testing were chosen based upon the consensus recommendations the TRT members. Modes of filter operation and ranges of recommended filtration rates were also agreed upon by the TRT members.

As solids accumulate in the media, column filtration rates decline. Periodic cleaning of these solids off the media is accomplished by reversing the flow direction (backwashing). A brief summary of the backwashing steps employed during pilot testing follows:

1. Provided approximately 6 inches (15 cm) water coverage over filter.

2. Applied 10 cfm (0.93 m^3/min) air scour for a 5-minute duration.

3. Kept applying 10 cfm air scour and initiated backwash at a flow rate of 2 gpm (7.6 L/min) for 2 minutes (the time required for the water level to reach 12 inches (300 mm) below the backwash water discharge line).

4. Before reaching the aforementioned water level (12 inches below discharge), gradually reduced the air scour rate to provide the stratified settling and prevent the loss of filter media.

5. After the adjustment of proper scour rates, backwash flow rates were increased to values indicated in **TABLE 2.2**.

6. Visual observations confirmed that no filter media was lost during backwash. The duration of each backwash phase is also shown in **TABLE 2.2.**

Filter 1C was the only filter column operated in the upflow mode. The applied filter media in this column was polystyrene. Due to its specific gravity, that media is buoyant. Steps for the backwashing of the polystyrene media include:

1. Dropped water level to approximately 12 inches (300 mm) over bottom discharge line.

2. Re-established normal filtration mode at 1.7 gpm (6.5 L/min) flow rate. In addition, applied air scour at 10 scfm (0.93 m^3/min) for approximately 2 minutes (the time required for the water level to reach 12 inches (300 mm) below the filtrate discharge line).

3. Shut off air scour.

4. Repeated steps 1 to 3 a minimum of 5 times.

The required frequency of filter backwash was a function of hydraulic as well as suspended solids loading rates. Filter backwash was initiated before either:

- Breakthrough (rapid increase of solids and/or phosphorus concentration in the filtrate), or
- Increased headloss resulting in a vacuum in the filter media.

2.1.5 Sampling Measurements and Analytical Techniques

Sampling Locations. Composite samplers were used to collect an approximate 75 milliliter aliqouts of sample at 15-minute intervals extending over an approximate 24-hour total compositing period. Ice was added to the outside jacket of each composite sampler and all samples were kept at 4 degrees Centigrade until collection. The unpreserved composite containers were then retrieved and carried into the on site field trailer for processing and preparing for shipment to the contract laboratory.

Composite sampling locations (ISCO programmable sampler) are shown in **FIGURE 2.4** and include:

1. Raw water;
2. Clarified water; and
3. Each filtrate stream.

Grab sampling locations (including grab composite sampling) are also shown in **FIGURE 2.4** and include:

1. Coagulants (alum, ferric-chloride, ferric-sulphate);
2. Coagulant aids (A-130 and A-1849 polyacrylamids); and
3. Residuals (clarifier sludge blow-down, filter backwash).

Flow metering (water and air) locations are provided as well in **FIGURE 2.4** and include:

1. Raw water (1 instantaneous and totalizer meter per trailer);
2. Filtrate (6 instantaneous and totalizer meters);
3. Instantaneous filter backwash; and
4. Instantaneous air scour.

Laboratory Analyses. There were three off-site laboratories involved in the analysis of the collected samples during the study period, including 1) DB Environmental Laboratories (DB Labs), 2) DEP Laboratories, and 3) Hydrosphere. DB Labs analyzed the phosphorus forms and suspended solids analyses. The DEP Laboratory was responsible for analyzing all metals, pesticides nitrogen tests and bioassay samples, with Hydrosphere Laboratory handling the bioassay overflow analyses. Specific analytical methods for each test performed by the laboratories during the CTSS testing are provided in **TABLE 4.4**, **TABLE 4.5** and **TABLE 4.6** of this Report's **APPENDIX 2**.

2.2 TEST DESIGN

There are numerous factors that have a potentially significant impact on the reduction of phosphorus concentration in aquatic environments using a chemical treatment technology. In such cases one of the main objectives of a test design is to screen the large number of potential variables and select the most important ones for detailed analysis. From among the numerous potentially important operational, environmental and water quality variables, seven system variables were selected for detailed investigation. The selection of key variables was reviewed and agreed to by the TRT. These variables or design factors include:

- Clarifier surface loading [a];
- Hydraulic filter loading [b];
- Coagulation hydraulic detention time [c];
- Coagulant dosage concentration [d];
- Polymer dosage concentration [e];
- Coagulant type [f]; and
- Filter media [g].

The design factors will be referred to in later parts of this Report by their designating letter shown in the brackets. The primary system response measured was the steady-state net reduction of Total P concentration reported as "µg/L."

There were a total of 201 trials (87 at the North Test Site and 114 at the South Test Site) conducted throughout the testing program. The large number of tests was grouped into 1) screening, 2) optimization, and 3) demonstration.

2.2.1 <u>Screening Tests</u>

A series of screening phase trials were conducted to investigate a broad range of potentially significant variables. The outcome of these screening trials answered some fundamental questions with pronounced impact on later optimization and demonstration trials. In particular, the preliminary tests were concerned with:

1. Familiarization with the pilot scale treatment system and sampling procedures;

2. Establishment of reduction kinetics of phosphorus species (*i.e.*, time required to establish steady-state net reduction of Total P in the system);

3. Recommendation of most effective filter media for a testing research phase(s);

4. Assessment of treatment chemical types and dosage concentrations;

5. Assessment of system performance at lowered pH (charge neutralization) conditions;

6. Establishment of sampling reproducibility (variance); and

7. Reporting correlation results between Total P concentrations and other environmental factors.

Design concepts and the setup of new trials, a few at a time, were developed as the testing progressed. Coded system variables for all 31 screening trials are shown in **TABLE 2.3**. Most of the screening tests were conducted for multipurpose analysis and they varied from 2 to 8 days. The actual length of each trial is shown in the second column ("days") in **TABLE 2.3**. All these screening tests are assigned with the capital letter "S" followed by the trial number.

2.2.2 Optimization Tests

After establishing baseline conditions with the screening tests, the primary objective of optimization was to generate data that could be used for optimizing phosphorus removal.

Since other phosphorus reduction projects (*e.g.*, CRA conducted microfiltration project) during the past several years had generated a significant amount of data, it was decided to use the '*Bayesian'* design approach. The principles of the '*Bayesian'* approach (which allows prior knowledge to testing) are outlined in Section 1.4 and described in detail elsewhere (Reilly, 1993). The capital letter "M" followed by either "N" for the North Test Site or "S" for the South Test Site followed by the trial number were assigned to each optimization test. The design of the optimization program is described below.

Based on the results of screening phase trials and with the review and concurrence of the TRT, the initially tested 6 filter media were reduced to the two best performing filter configurations, which were the "Swiss" and "Green Everglades" media. The Green Everglades or "GE" filter is somewhat similar to the formerly tested "LA" filter configuration. **TABLE 2.4** provides a summary of the media used during the optimization testing.

'Bayesian' testing is based on the principle of learning from experience as stated previously. It is common practice to design approximately 25 percent of the anticipated number of trials at a time. Accordingly, a total of 70 trials at the North Test Site and 68 trials at the South Test Site were designed. Both of these series of trials were designed in four distinct segments. Screening phase results and a review of published literature provided the prior information for the design of the first segment. The total number of trials was 22 in this segment, 16 of those were designed according to '*Bayesian'* principles. The additional six trials addressed specific testing conditions. The coded design matrices for the North and South Test Sites are shown in **TABLE 2.5** and **TABLE 2.6**, respectively. After the completion of the first design segment, the results were evaluated and supplemented to the previous prior distribution resulting in improved prior information for the design of the second segment. The second segment consisted of 16 additional trials designed according to the '*Bayesian'* approach (**TABLE 2.7** and **TABLE 2.8**).

The total number of tests in the third segment was 14 at both Test Sites. The coded design matrices for the North and South Test Sites are shown in **TABLE 2.9** and **TABLE 2.10**, respectively. Trials in this segment were designed to investigate specific testing conditions (*e.g.*, direct filtration) and could not be used for model building. Two tests were performed with higher than the intended coagulant dosage concentration in the previous segment. These trials were repeated with the correct dosage concentration in this segment (Tests MN39 and MN40).

Before the design of the fourth segment, the design level of two of the factors (coagulation volume and clarifier surface loading) were increased from 2 to 3 (*e.g.*, 20, 200 and 220 gallons). In addition, all the '*Bayesian'*-designed tests were grouped together and considered as the prior information for the design of the last segment. Since the design of the fourth segment is typical, the design of this segment is provided in **APPENDIX 1.2**. **TABLE 2.11** and **TABLE 2.12** provide the resulting Segment #4 test protocols for the North and South Test Sites, respectively.

2.2.3 Demonstration Tests

The primary objective of the last testing phase was two-fold: 1) to demonstrate that the conventional water treatment process can be operated in such condition(s) that its final effluent meets, on a consistent basis, the Total P criteria of 10 micrograms per liter, and 2) to obtain process design data for developing full scale conceptual treatment systems.

After reviewing data obtained during the optimization phase, conditions for the demonstration phase testing were selected with input from members of the CTSS project team and from the technical review team members. **TABLE 2.13** shows the coded design matrix for the demonstration testing.

Demonstration testing was conducted during the time period December 4 through December 23, 1999.

2.2.4 Residual Solids Management and Testing

Residual solids generated from the CTSS flocculation process were allowed to concentrate via gravity settling in the clarifier underdrain chamber. During clarifier operation, these underdrain solids were periodically pumped at an average rate of 0.6 gallons per minute into the two 2500-gallon residual solids storage facilities (one dedicated for alum residuals and the other for iron) located adjacent to the treatment trailers. Solids were allowed to settle in these tanks using a minimum hydraulic retention time of approximately two days and the supernatant overflow was returned to the ENR. Long-term storage of additional residual solids was also accomplished in two lined, in-ground basins each possessing approximately 20,000-gallon capacity.

At the end of the CTSS demonstration phase, all of the solids were chemically tested for the full suite of toxicity characteristics leaching procedure (TCLP) organic and metal parameters and then portions were used for additional residuals testing including:

- Dewatering testing by means of belt press, filter press and centrifugation; and
- Land application trials at EAA sweet corn test plots.

Details of these land application trials and dewatering and testing results are provided in Section 3 of this Report.

2.2.5 Vendor Technologies

Aside from the CTSS pilot facility, other technologies have been identified as being potentially able to substantially reduce the Total P content of the EAA surface waters. Throughout the course of the field testing trials lasting from June to December of 1999, various vendor technologies were tested to determine their phosphorus removal potential. Some of these trials were limited to HSA personnel testing proprietary polymer mixes using the onsite jar testing apparatus and submitting resulting water samples to the lab for assessment. Other vendors were contracted to conduct pilot testing trials at the ENR North and South Test Sites for periods of time. **TABLE 2.14** provides a summary of all of the vendor technologies that were testing during the CTSS field trials. **TABLE 2.14** also provides the size of the pilot facilities (if any) used and the dates testing occurred. Details of vendor trials and associated results are provided in Section 4 of the report.

2.2.6 Additional Testing

During the CTSS field trials, testing of influent and effluent samples for low level mercury and for biotoxicity testing was also completed.

SFWMD field personnel collected samples for the low level mercury analyses during the CTSS Demonstration testing period. Analyses were performed for:

- Total mercury;
- Filtered total mercury;
- Total methyl mercury; and
- Filtered methyl mercury.

Biotoxicity and Algal Growth Potential (AGP) analyses were collected on representative influent and effluent CTSS samples and analyzed by the FDEP Laboratory in Tallahassee, Florida. During the latter phase of demonstration testing, Hydrosphere Laboratory (located in Gainesville, Florida) served as an overflow bioassay lab and also conducted a few of the biotoxicity tests as well. Tests conducted include the following:

- Seven-day chronic estimator (screening) tests using the bannerfin shiner (*Cyprinella Leedsi*) test;
- Seven-day chronic estimator (screening) tests using the water flea (*Ceriodaphnia Dubia*) test; and
- A 96-hour growth test using the unicellular green alga (*Selenastrum Capricornutum*) test.

Tests were performed following USEPA guidelines, but substituting *C. Leedsi* for the fathead minnow, *Pimephales Promelas* (EPA/600/4-91/002). Algal Growth Potential (AGP) tests were performed on the influent and were conducted following USEPA guidelines (EPA/600/9-78-018).

FIGURE 2.1a - Pilot Unit Filter Columns

FIGURE 2.1b - Laboratory Trailer Testing Equipment

FIGURE 2.2a - Residual Solids Storage

FIGURE 2.2b - Pilot Unit Treatment Trailer

FIGURE 2.3a - Treatment Trailer and Process Tanks

FIGURE 2.3b - Residuals Holding Ponds

FIGURE 2.4
Schematic Diagram of CTSS Pilot Facility Showing Various Sampling Locations

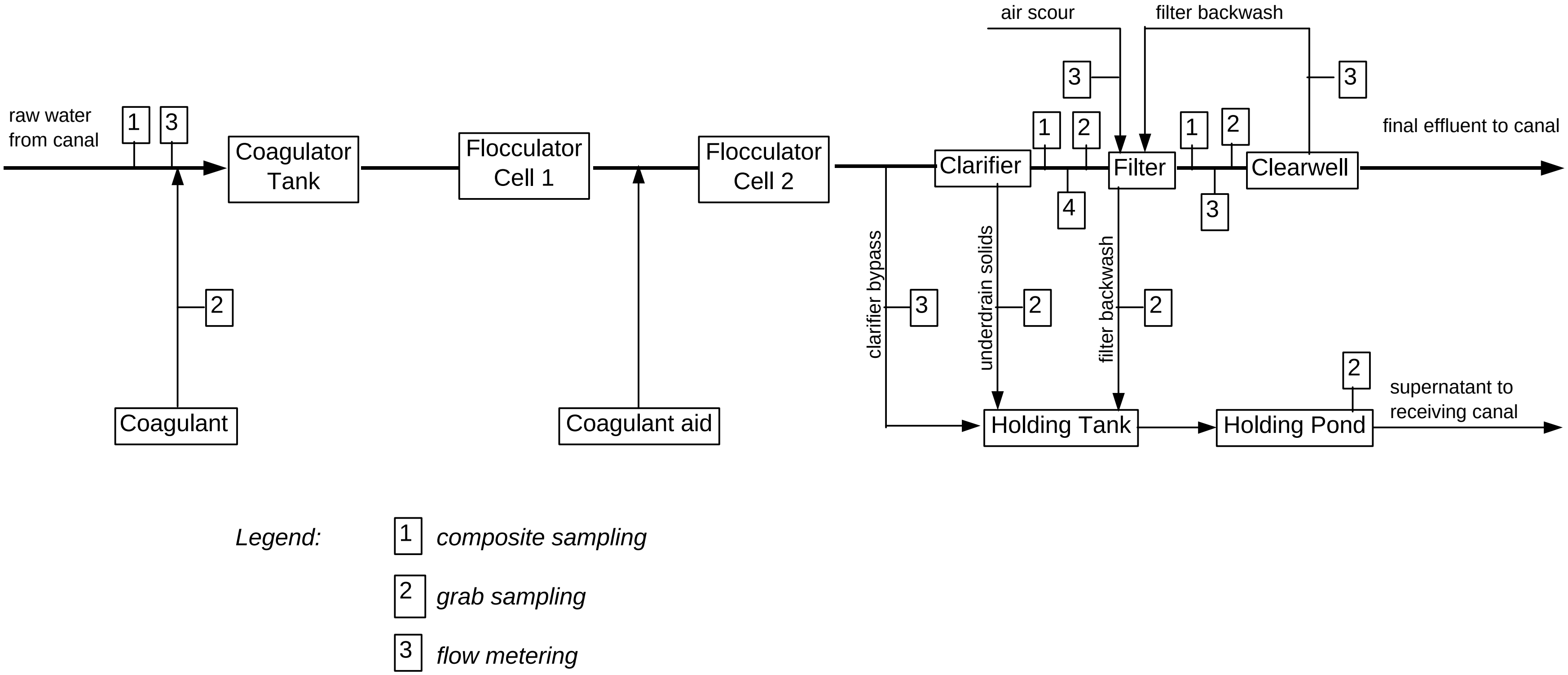

TABLE 2.1
DESCRIPTION OF FILTERS USED DURING SCREENING TRIALS

FILTER			FILTER MEDIA							
No.	**Designation**	**Layer**	**Type**	**Depth (inches)**	**ES* (mm)**	**UC** (-)**	**d_{60} (mm)**	**Description *** **	**Sphericity (φ)**	**Porosity (n)**
1A	LA	mono	Anthracite	77.5	1.5	1.6	2.4	'sharp'	0.81	0.40
1B	Swiss	top	Expanded shale	40	N/A	N/A	2 – 3	'crushed'	0.70	0.48
		bottom	Sand	12	1.5	1.5	2.25	'spherical'	1.00	0.38
1C	Polystyrene ****	mono	Polystyrene	96	N/A	N/A	2 – 3	'spherical'	1.00	0.38
2A	Humics	top	Anthracite	16 ½	2.0	1.5	3.0	'sharp'	0.81	0.40
		bottom	Sand	31	1.5	1.5	2.25	'spherical'	1.00	0.38
2B	Wahnbach	top	GAC	15	N/A	N/A	3 – 5	'angular'	0.78	0.43
		middle	Anthracite	47	1.5	1.6	2.4	'sharp'	0.81	0.40
		bottom	Sand	20	0.8	1.6	1.28	'spherical'	1.00	0.38
2C	Shale	mono	Expanded shale	70 ½	N/A	N/A	2 – 3	'worn'	0.94	0.39

Notes:
* *effective size (d_{10}) as reported by Metcalf & Eddy Ltd.*
** *uniformity coefficient (d_{60}/d_{10}) as reported by Metcalf & Eddy Ltd.*
*** *as observed by CRA*
**** *upflow filtration (all other reported filters are operated in downflow mode)*

TABLE 2.2
FILTER BACKWASH PROCEDURES

Filter No.	Initial Water Coverage over Media (inches)	Step #1		Step #2			Step #3		
		Air Scour Flow Rate (scfm)	Duration (minutes)	Air Scour Flow Rate (scfm)	Filtrate Flow Rate (gpm)	Duration* (minutes)	Air Scour Flow Rate (scfm)	Filtrate Flow Rate (gpm)	Duration (minutes)
1A	6	10	5	10	2	2	**<u>no</u> air scour**	22 gpm	10
1B	6	10	5	10	2	2	0.2	22 gpm	10
1C**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2A	6	10	5	10	2	2	0.2	22 gpm	10
2B	6	10	5	10	2	2	**<u>no</u> air scour**	22 gpm	10
2C	6	10	5	10	2	2	0.4	22 gpm	10

Notes: * *approximate time of rising water level to reach 12 inches (30 cm) below waste discharge line*
** *special filter backwash procedure applies*

TABLE 2.3
Design Matrix – Screening Phase Trials
South Test Site (June 03, 1999 to September 25, 1999)

Exp #	Days	Operational Variables: Dosage Concentration of Treatment Chemicals				Sludge Discharge		Hydraulic Loading	
		$Al_2(SO_4)_3$ (mg/L) as AL	$Fe_2(SO_4)_3$ (mg/L) as Fe	$Ca(OH)_2$ (mg/L)	A-1849 (mg/L)	Wasted (%)	Recycled (%)	Clarifier* (gpm/sq.ft.)	Filter (gpm/sq.ft.)
S1	1 - 6	none	none	none	none	2	none	0.43	4.9
S2	1 - 6	12	none	none	none	2	none	0.71	-
S3	7 - 15	12	none	none	0.5	2	none	0.43	4.9
S4	7 - 15	none	3.5	50	none	2	none	0.43	4.9
S5	16–19	10	none	none	0.5	2	none	0.43	6.0
S6	16-19	none	1.5	50	none	2	none	0.43	6.0
S7	20-27	10	none	none	0.3	2	none	0.43	6.0
S8	20-27	none	10	none	none	2	none	0.71 **	-
S9	28-30	10	none	none	none	-	-	-	6.0
S10	28-30	none	10	none	0.3	2	none	0.28	-
S11	31-34	10	none	none	none	-	-	-	4.9
S12	32-35	10	none	none	0.3	2	none	0.28	-
S13	31-34	none	10	none	none	-	-	-	4.9
S14	33-35	none	10	none	0.3	2	none	0.28	-
S15	36-39	none	10	none	none	-	-	-	4.9
S16	36-39	10	none	none	0.3	2	16	0.28	-
S17	36-39	10	none	none	none	-	-	-	4.9
S18	36-39	none	10	none	0.3	1	16	0.28	-
S19	41-42	10	none	none	none	-	-	-	4.9
S20	40-44	10	none	none	0.3	2	33	0.14	-
S21	41-42	none	10	none	none	-	-	-	4.9
S22	40-44	none	10	none	0.3	2	33	0.14	-
S23	45-49	10	none	none	0.1	2	33	0.14	4.9
S24	45-49	none	20	none	0.1	2	33	0.14	4.9
S25	50-56	10	none	none	0.1	-	-	-	4.9
S26	51-56	none	20	none	0.1	-	-	-	4.9
S27	57-61	10	none	none	0.1	2	none	0.43	4.9
S28	57-61	none	20	none	0.1	2	none	0.43	4.9
S29	62-64	10	none	none	0.3	5	none	0.43	4.9
S30	65-67	none	20	none	0.3	5	none	0.43	4.9
S31***	66-67	none	none	none	none	none	none	0.43	4.9

Notes:

Tests 1, 3, and 4 — *suction filtration (constant rate filtration provided by downstream pumping)*

Tests 5, 6, 7, 9 — *downstream controlled gravity filtration (constant rate followed by declining rate filtration provided by gradual opening of effluent va*

Tests 11, 13, 15, 17, 19, 21, 23, 24, 25, 26, 27, 28, 29, 30, and 31 — *declining rate gravity filtration (constant valve setting; operation from 1.3Q to 0.6Q, where Q is the target hydraulic loading)*

* — *based on 28 ft^2 projected lamella area*

** — *0.43 gpm/sq.ft. in days 23 to 26*

*** — *North Test Site data*

S — *South Test Site*

TABLE 2.4
Filters and Filter Media Parameters for
Optimization and Demonstration Trials

Filter			Filter Media						
No.	**Designation**	**Layer**	**Type**	**Depth (inches)**	**ES* (mm)**	**UC** (-)**	**Description *** **	**Sphericity (φ)**	**Porosity (n)**
North Test Site									
1A	GE	top	anthracite	24	2.0	1.4	'sharp'	0.81	0.40
		middle	sand	31	1.1	1.4	'spherical'	1.00	0.38
		bottom	gravel	4	N/A	N/A	'crushed'	0.70	0.48
1B	Swiss	top	expanded shale	43	2-3	N/A	'crushed'	0.70	0.48
		middle	sand	12	1.5	1.4	'spherical'	1.00	0.38
		bottom	gravel	4	N/A	N/A	'crushed'	0.70	0.48
1C	GE****	top	anthracite	24	2.0	1.4	'sharp'	0.81	0.40
		middle	sand	31	1.1	1.4	'spherical'	1.00	0.38
		bottom	gravel	4	N/A	N/A	'crushed'	0.70	0.48
South Test Site									
2A	Swiss	top	expanded shale	43	2-3	N/A	'crushed'	0.70	0.48
		middle	sand	12	1.5	1.4	'spherical'	1.00	0.38
		bottom	gravel	4	N/A	N/A	'crushed'	0.70	0.48
2B	Swiss****	top	expanded shale	43	2-3	N/A	'crushed'	0.70	0.48
		middle	sand	12	1.5	1.4	'spherical'	1.00	0.38
		bottom	gravel	4	N/A	N/A	'crushed'	0.70	0.48
2C	GE	top	anthracite	24	2.0	1.4	'sharp'	0.81	0.40
		middle	sand	31	1.1	1.4	'spherical'	1.00	0.38
		bottom	gravel	4	N/A	N/A	'crushed'	0.70	0.48

Notes:
* *effective size (d_{10}) as reported by Metcalf & Eddy Ltd.*
** *uniformity coefficient (d_{60}/d_{10}) as reported by Metcalf & Eddy Ltd.*
*** *as observed by CRA*
**** *filters were not used during demonstration*
N/A *not available*

TABLE 2.5
Coded Design Matrix – Optimization Trials
North Test Site - Segment #1 (October 26, 1999 to November 7, 1999)

Date	Exp #	Variable						
1999		Filter Media - 'Swiss' + 'GE'	Hydraulic Filter Loading* - 4.9 gpm/sq.ft. + 9.8 gpm/sq.ft.	Coagulation Volume - 220 gallons + 200 gallons	Clarifier Surface Loading** - 0.28 gpm/sq.ft. + 0.43 gpm/sq.ft.	Coagulant Type - alum + ferric-chloride	Coagulant Dosage Concentration alum: - 10 mg/L as Al + 20 mg/L as Al ferric-chloride: - 20 mg/L as Fe + 40 mg/L as Fe	Polymer (A-130) Dosage Concentration - 0.3 mg/L + 0.5 mg/L
October 26	MN1	-	-	+	-	-	-	+
(Tuesday)	MN2	+	-	+	-	-	-	+
October 27	MN3	-	+	+	+	+	+	+
(Wednesday)	MN4	+	+	+	+	+	+	+
October 28♦♦♦	MN5	-	+	-***	-	+	+	-
(Thursday)	MN6	+	+	-***	-	+	+	-
October 29	MN7	-	+	-	-	+	+	-
(Friday)	MN8	+	+	-	-	+	+	-
November 1	MN9	-	+	-	-	+	-	+
(Monday)	MN0	+	+	-	-	+	-	+
November 2	MN11	-	+	-	-	-	+	+
(Tuesday)	MN12	+	+	-	-	-	+	+
November 3	MN13	-	+	+	-	-	-	-
(Wednesday)	MN14	+	+	+	-	-	-	-
November 4	MN15	-	-	-	-	+	+	+
(Thursday)	MN16	+	-	-	-	+	+	+
November 5	MN17	-	-	+	-	-	+	-
(Friday)	MN18	+	-	+	-	-	+	-
November 6♦♦♦	MN19	-	-	-	-	-	+	+****
(Saturday)	MN20	+	-	-	-	-	+	+****
November 7♦♦♦	MN21	-	-	-	-	+	+	+****
(Sunday)	MN22	+	-	-	-	+	+	+****

Notes:
- * *4.9 gpm/sq.ft. (1.7 gpm hydraulic filter loading)*
- ** *projected lamella area*
- *** *20 gallons*
- **** *A-1849 polyacrylamide*
- ♦ *lab duplicate*
- ♦♦ *filter duplicate*
- ♦♦♦ ***tests** in addition to Bayesian designed trials*
- *M model building or optimization trials*
- *N North Test Site*

Constant flocculation volume is 400 gallons
Even number tests will be conducted in duplicate using the Green Everglades (GE) filter media
Filter 1A: 'Green Everglades'; filter 1B: 'Swiss'; filter 1C: 'Green Everglades'

The "-" and "+" signs designate the variable to be used in a given test. For instance, in Test in N1, the "-" under filter media means that the 'Swiss' filter was used; the "-" under hydraulic filter loading means that 4.9 gpm/sq.ft. was used.

TABLE 2.6
Coded Design Matrix – Optimization Trials
South Test Site - Segment #1 (October 26, 1999 to November 7, 1999)

Date	Exp #	Variable						
1999		Filter Media - ‘Swiss’ + ‘GE’	Hydraulic Filter Loading* - 4.9 gpm/sq.ft. + 9.8 gpm/sq.ft.	Coagulation Volume - 220 gallons + 200 gallons	Clarifier Surface Loading** - 0.28 gpm/sq.ft. + 0.43 gpm/sq.ft.	Coagulant Type - alum + ferric-chloride	Coagulant Dosage Concentration alum: - 10 mg/L as Al + 20 mg/L as Al ferric-chloride: - 20 mg/L as Fe + 40 mg/L as Fe	Polymer (A-130) Dosage Concentration - 0.3 mg/L + 0.5 mg/L
October 26	MS1	-	-	+	-	-	-	+
(Tuesday)	MS2	+	-	+	-	-	-	+
October 27	MS3	-	+	+	+	+	+	+
(Wednesday)	MS4	+	+	+	+	+	+	+
October 28♦♦♦	MS5	-	+	-***	-	+	+	-
(Thursday)	MS6	+	+	-***	-	+	+	-
October 29	MS7	-	+	-	-	+	+	-
(Friday)	MS8	+	+	-	-	+	+	-
November 1	MS9	-	+	-	-	+	-	+
(Monday)	MS10	+	+	-	-	+	-	+
November 2	MS11	-	+	-	-	-	+	+
(Tuesday)	MS12	+	+	-	-	-	+	+
November 3	MS13	-	+	+	-	-	-	-
(Wednesday)	MS14	+	+	+	-	-	-	-
November 4	MS15	-	-	-	-	+	+	+
(Thursday)	MS16	+	-	-	-	+	+	+
November 5	MS17	-	-	+	-	-	+	-
(Friday)	MS18	+	-	+	-	-	+	-
November 6♦♦♦	MS19	-	-	-	-	-	+	+****
(Saturday)	MS20	+	-	-	-	-	+	+****
November 7♦♦♦	MS21	-	-	-	-	+	+	+****
(Sunday)	MS22	+	-	-	-	+	+	+****

Notes:

Notes:	*	*4.9 gpm/sq.ft. (1.7 gpm hydraulic filter loading)*
	**	*projected lamella area*
	***	*20 gallons*
	****	*A-1849 polyacrylamide*
	♦	*lab duplicate*
	♦♦	*filter duplicate*
	♦♦♦	***tests** in addition to ‘Bayesian’ designed trials*
	M	*model building or optimization trials*
	S	*South Test Site*

Constant flocculation volume is 400 gallons
Uneven number tests will be conducted in duplicate using the ‘Swiss’ filter media
Filter 2A: ‘Swiss’; filter 2B: ‘Swiss’; filter 2C: ‘Green Everglades’

TABLE 2.7
Coded Design Matrix – Optimization Trials
North Test Site - Segment #2 (November 8, 1999 to November 15, 1999)

Date	Exp #	Variable						
1999		Filter Media - 'Swiss' + 'GE'	Hydraulic Filter Loading* - 4.9 gpm/sq.ft. + 9.8 gpm/sq.ft.	Coagulation Volume - 220 gallons + 200 gallons	Clarifier Surface Loading** - 0.28 gpm/sq.ft. + 0.43 gpm/sq.ft.	Coagulant Type - alum + ferric-chloride	Coagulant Dosage Concentration alum: - 10 mg/L as Al + 20 mg/L as Al ferric-chloride: - 20 mg/L as Fe + 40 mg/L as Fe	Polymer (A-130) Dosage Concentration - 0.3 mg/L + 0.5 mg/L
November 8	**MN23**	-	+	+	-	-	+	+
(Monday)	**MN24**	+	+	+	-	-	+	+
November 9	**MN25**	-	+	+	-	-	-	+
(Tuesday)	**MN26**	+	+	+	-	-	-	+
November 10	**MN27**	-	+	+	+	+	-	+
(Wednesday)	**MN28**	+	+	+	+	+	-	+
November 11♦♦♦	**MN29**	-	+	+	+	+	+***	-
(Thursday)	**MN30**	+	+	+	+	+	+***	-
November 12	**MN31**	-	-	+	+	+	+	+
(Friday)	**MN32**	+	-	+	+	+	+	+
November 13	**MN33**	-	-	+	-	+	-	-
(Saturday)	**MN34**	+	-	+	-	+	-	-
November 14	**MN35**	-	+	-	+	-	+	+
(Sunday)	**MN36**	+	+	-	+	-	+	+
November 15	**MN37**	-	-	-	-	+	+	-
(Monday)	**MN38**	+	-	-	-	+	+	-

Notes:
- * *4.9 gpm/sq.ft. (1.7 gpm hydraulic filter loading)*
- ** *projected lamella area*
- *** *100 mg/L as Fe*
- ♦ *lab duplicate*
- ♦♦ *filter duplicate*
- ♦♦♦ ***test**(s), in addition to 'Bayesian' designed trials*
- *M model building or optimization trials*
- *N North Test Site*

Constant flocculation volume is 400 gallons
Even number tests will be conducted in duplicate using the Green Everglades (GE) filter media
Filter 1A: 'Green Everglades'; filter 1B: 'Swiss'; filter 1C: 'Green Everglades'

TABLE 2.8
Coded Design Matrix – Optimization Trials
South Test Site - Segment #2 (November 8, 1999 to November 15, 1999)

Date	Exp #	Variable						
1999		Filter Media - 'Swiss' + 'GE'	Hydraulic Filter Loading* - 4.9 gpm/sq.ft. + 9.8 gpm/sq.ft.	Coagulation Volume - 220 gallons + 200 gallons	Clarifier Surface Loading** - 0.28 gpm/sq.ft. + 0.43 gpm/sq.ft.	Coagulant Type - alum + ferric-chloride	Coagulant Dosage Concentration alum: - 10 mg/L as Al + 20 mg/L as Al ferric-chloride - 20 mg/L as Fe + 40 mg/L as Fe	Polymer (A-130) Dosage Concentration - 0.3 mg/L + 0.5 mg/L
November 8	MS23	-	+	+	-	-	+	+
(Monday)	MS24	+	+	+	-	-	+	+
November 9	MS25	-	+	+	-	-	-	+
(Tuesday)	MS26	+	+	+	-	-	-	+
November 10	MS27	-	+	+	+	+	-	+
(Wednesday)	MS28	+	+	+	+	+	-	+
November 11	MS29	-	+	+	+	+	+	-
(Thursday)	MS30	+	+	+	+	+	+	-
November 12	MS31	-	-	+	+	+	+	+
(Friday)	MS32	+	-	+	+	+	+	+
November 13	MS33	-	-	+	-	+	-	-
(Saturday)	MS34	+	-	+	-	+	-	-
November 14	MS35	-	+	-	+	-	+	+
(Sunday)	MS36	+	+	-	+	-	+	+
November 15	MS37	-	-	-	-	+	+	-
(Monday)	MS38	+	-	-	-	+	+	-

Notes:
- * *4.9 gpm/sq.ft. (1.7 gpm hydraulic filter loading)*
- ** *projected lamella area*
- ♦ *lab duplicate*
- ♦♦ *filter duplicate*
- M *model building or optimization trials*
- S *South Test Site*

Constant flocculation volume: 400 gallons
Uneven number tests will be conducted in duplicate using the 'Swiss' filter media
Filter 2A: 'Swiss'; filter 2B: 'Swiss'; filter 2C: 'Green Everglades'

TABLE 2.9
Coded Design Matrix – Optimization Trials
North Test Site - Segment #3 (November 16, 1999 to November 21, 1999)

Date	Exp #	Variable						
1999		Filter Media - 'Swiss' + 'GE'	Hydraulic Filter Loading* - 4.9 gpm/sq.ft. + 9.8 gpm/sq.ft.	Coagulation Volume - 20 gallons 0.8 200 gallons + 220 gallons	Clarifier Surface Loading** -2 none - 0.14 gpm/sq.ft. 0 0.28 gpm/sq.ft. + 0.43 gpm/sq.ft.	Coagulant Type - alum + ferric-chloride	Coagulant Dosage Concentration alum: - 10 mg/L as Al + 20 mg/L as Al ferric-chloride: - 20 mg/L as Fe + 40 mg/L as Fe	Polymer (A-130) Dosage Concentration - 0.3 mg/L + 0.5 mg/L
November 16	MN39	-	+	0.8	+	+	+	-
(Tuesday)***	MN40	+	+	0.8	+	+	+	-
November 17♦♦♦	MN41	-	-	+	-2	+	-	-
(a.m.)	MN42	+	-	+	-2	+	-	-
November 17♦♦♦	MN43	-	-	+	-2	+	+	-
(p.m.)	MN44	+	-	+	-2	+	+	-
November 18♦♦♦	MN45	-	-	+	-2	-	-	-
(a.m.)	MN46	+	-	+	-2	-	-	-
November 18♦♦♦	MN47	-	-	+	-2	-	+	-
(p.m.)	MN48	+	-	+	-2	-	+	-
November 19♦♦♦	MN49	-	-	+	-	-	+	+
(Friday)	MN50	+	-	+	-	-	+	+
Nov ember 20♦♦♦	MN51	-	-	+	-	+	+	+
(Saturday)	MN52	+	-	+	-	+	+	+
November 21♦♦♦	MN53	-	-	+	-	+	+	+
(Sunday)	MN54	+	-	+	-	+	+	+

Notes: *Constant flocculation volume: 400 gallons*
HDT in a single flocculator cell: 49 min 30 sec (Q_{feed} = 4 gpm) unless noted
* *4.9 gpm/sq.ft. (1.7 gpm hydraulic filter loading)*
** *projected lamella area*
*** *HDT in a single flocculator cell: 16 min 30 sec (Q_{feed} = 12 gpm)*
♦ *lab duplicate*
♦♦ *filter duplicate*
♦♦♦ ***tests*** *in addition to 'Bayesian' designed trials*
M *model building or optimization trials*
N *North Test Site*
Even number tests will be conducted in duplicate using the Green Everglades (GE) filter media
Filter 1A: 'Green Everglades'; filter 1B: 'Swiss'; filter 1C: 'Green Everglades'

TABLE 2.10
Coded Design Matrix – Optimization Trials
South Test Site - Segment #3 (November 17, 1999 to November 21, 1999)

Date	Exp #	Variable						
1999		Filter Media - 'Swiss' + 'GE'	Hydraulic Filter Loading* - 4.9 gpm/sq.ft. + 9.8 gpm/sq.ft.	Coagulation Volume - 20 gallons 0.8 200 gallons + 220 gallons	Clarifier Surface Loading** -2 none - 0.14 gpm/sq.ft. 0 0.28 gpm/sq.ft. + 0.43 gpm/sq.ft.	Coagulant Type - alum + ferric-chloride	Coagulant Dosage Concentration alum: - 10 mg/L as Al + 20 mg/L as Al ferric-chloride: - 20 mg/L as Fe + 40 mg/L as Fe	Polymer (A-130) Dosage Concentration - 0.3 mg/L + 0.5 mg/L
November 16♦♦♦♦								
(Tuesday)								
November 17♦♦♦	MS39	-	-	+	-2	+	-	-
(a.m.)	MS40	+	-	+	-2	+	-	-
November 17♦♦♦	MS41	-	-	+	-2	+	+	-
(p.m.)	MS42	+	-	+	-2	+	+	-
November 18♦♦♦	MS43	-	-	+	-2	-	-	-
(a.m.)	MS44	+	-	+	-2	-	-	-
November 18♦♦♦	MS45	-	-	+	-2	-	+	-
(p.m.)	MS46	+	-	+	-2	-	+	-
November 19♦♦♦	MS47	-	-	+	-	-	+	+
(Friday)	MS48	+	-	+	-	-	+	+
November 20♦♦♦	MS49	-	-	+	-	+	+	+
(Saturday)	MS50	+	-	+	-	+	+	+
November 21♦♦♦	MS51	-	-	+	-	+	+	+
(Sunday)	MS52	+	-	+	-	+	+	+

Notes: *Constant flocculation volume is 400 gallons unless noted*
Constant HDT in a single flocculator cell: 49 min 30 sec (Q_{feed} = 4 gpm) unless noted
* *4.9 gpm/sq.ft. (1.7 gpm hydraulic filter loading)*
** *projected lamella area*
♦ *lab duplicate*
♦♦ *filter duplicate*
♦♦♦ *test(s), in addition to 'Bayesian' design*
♦♦♦♦ *test was not conducted*
M *model building or optimization trials*
S *South Test Site*
Uneven number tests will be conducted in duplicate using the 'Swiss' filter media
Filter 2A: 'Swiss'; filter 1B: 'Swiss'; filter 1C: 'Green Everglades'

TABLE 2.11
Coded Design Matrix – Optimization Trials
North Test Site - Segment #4 (November 22, 1999 to December 3, 1999)

Date	Exp #	Variable						
1999		Filter Media - 'Swiss' + 'GE'	Hydraulic Filter Loading* - 4.9 gpm/sq.ft. + 9.8 gpm/sq.ft.	Coagulation Volume - 20 gallons 0.8 200 gallons + 220 gallons	Clarifier Surface Loading** - 0.14 gpm/sq.ft. 0 0.28 gpm/sq.ft. + 0.43 gpm/sq.ft.	Coagulant Type - alum + ferric-chloride	Coagulant Dosage Concentration alum: - 10 mg/L as Al + 20 mg/L as Al ferric-chloride: - 20 mg/L as Fe + 40 mg/L as Fe	Polymer (A-130) Dosage Concentration - 0.3 mg/L + 0.5 mg/L
November 22	**MN55**	-	-	-	+	-	-	-
(Monday)	**MN56**	+	-	-	+	-	-	-
November 23	**MN57**	-	-	-	-	-	+	+
(Tuesday)	**MN58**	+	-	-	-	-	+	+
November 24	**MN59**	-	-	-	-	+	-	+
(Wednesday)	**MN60**	+	-	-	-	+	-	+
November 29♦♦♦	**MN61**	-	-	+	-	-	-	-
(Monday)	**MN62**	+	-	+	-	-	-	-
November 30♦♦♦	**MN63**	-	+	+	-	-	+	-
(Tuesday)	**MN64**	+	+	+	-	-	+	-
December 1♦♦♦	**MN65**	-	-	+	-	+	+	+
(Wednesday)	**MN66**	+	-	+	-	+	+	+
December 2♦♦♦	**MN67**	-	+	+	-	+	-	+
(Thursday)	**MN68**	+	+	+	-	+	-	+
December 3♦♦♦	**MN69**	-	+	+	-	+	-	-
(Friday)	**MN70**	+	+	+	-	+	-	-

Notes:
- ** 4.9 gpm/sq.ft. (1.7 gpm hydraulic filter loading)*
- *** projected lamella area*
- *♦ lab duplicate*
- *♦♦ filter duplicate*
- *♦♦♦ tests in addition to 'Bayesian' designed trials*
- *M model building or optimization trials*
- *N North Test Site*

Constant flocculation volume: 400 gallons
Even number tests will be conducted in duplicate using the Green Everglades (GE) filter media
Filter 1A: 'Green Everglades'; filter 1B: 'Swiss'; filter 1C: 'Green Everglades'

TABLE 2.12
Coded Design Matrix – Optimization Trials
South Test Site - Segment #4 (November 22, 1999 to December 3, 1999)

Date	Exp #	Variable						
1999		Filter Media - 'Swiss' + 'GE'	Hydraulic Filter Loading* - 4.9 gpm/sq.ft. + 9.8 gpm/sq.ft.	Coagulation Volume - 20 gallons 0.8 200 gallons + 220 gallons	Clarifier Surface Loading** - 0.14 gpm/sq.ft. 0 0.28 gpm/sq.ft. + 0.43 gpm/sq.ft.	Coagulant Type - alum + ferric-chloride	Coagulant Dosage Concentration alum: - 10 mg/L as Al + 20 mg/L as Al ferric-chloride: - 20 mg/L as Fe + 40 mg/L as Fe	Polymer (A-130) Dosage Concentration - 0.3 mg/L + 0.5 mg/L
November 22	MS53	-	-	-	+	-	-	-
(Monday)	MS54	+	-	-	+	-	-	-
November 23	MS55	-	-	-	-	-	+	+
(Tuesday)	MS56	+	-	-	-	-	+	+
November 24	MS57	-	-	-	-	+	-	+
(Wednesday)	MS58	+	-	-	-	+	-	+
November 29♦♦♦	MS59	-	-	+	-	-	-	-
(Monday)	MS60	+	-	+	-	-	-	-
November 30♦♦♦	MS61	-	+	+	-	-	+	-
(Tuesday)	MS62	+	+	+	-	-	+	-
December 1♦♦♦	MS63	-	-	+	-	+	+	+
(Wednesday)	MS64	+	-	+	-	+	+	+
December 2♦♦♦	MS65	-	+	+	-	+	-	+
(Thursday)	MS66	+	+	+	-	+	-	+
December 3♦♦♦	MS67	-	+	+	-	+	-	-
(Friday)	MS68	+	+	+	-	+	-	-

Notes:
- * *4.9 gpm/sq.ft. (1.7 gpm hydraulic filter loading)*
- ** *projected lamella area*
- ♦ *lab duplicate*
- ♦♦ *filter duplicate*
- ♦♦♦ *tests in addition to 'Bayesian' designed trials*
- M *model building or optimization trials*
- S *South Test Site*

Constant flocculation volume: 400 gallons
Uneven number tests will be conducted in duplicate using the Green Everglades (GE) filter media
Filter 2A: 'Swiss'; filter 2B: 'Swiss'; filter 2C: 'Green Everglades'

TABLE 2.13
Coded Design Matrix – Demonstration Trials
North and South Test Sites (December 4, 1999 to December 23, 1999)

Test Site	Variable					
	Hydraulic Filter Loading (gpm/sq.ft.) - 4.9 gpm/sq.ft. + 9.8 gpm/sq.ft.	**Coagulation Volume (gallons)** - 20 gallons 0.8 200 gallons + 220 gallons	**Clarifier Surface Loading (gpm/sq.ft.)** - 0.14 gpm/sq.ft. 0 0.28 gpm/sq.ft. + 0.43 gpm/sq.ft.	**Coagulant Type** - alum + ferric-chloride	**Coagulant Dosage Concentration (mg/L)*** alum: - 10 mg/L + 20 mg/L ferric-chloride: - 20 mg/L + 40 mg/L	**Polymer** Dosage Concentration (mg/L)** - 0.3 mg/L + 0.5 mg/L
North	-	-	-	+	+	+
South	+	-	0	-	+	+

Notes: * *as metal*
** *A-130 polyacrylamide*

TABLE 2.14
Vendor Technologies Tested During CTSS Field Investigations

Vendor	Treatment Process		Test Location	Test Duration (1999)	Area (L x W x H) (feet)	Electrical	Hydraulic Loading (gpm)*		Process Chemicals
	Name	Description					Max	Tested	
F.B. Leopold Company	Dissolved Air Flotation (DAF)	solids-liquid separation process that transfers solids to the liquid surface through attachment of fine bubbles to solid particles	South Site North Site	Oct 11 - Oct 15 Oct 18 – Oct 24	11' x 54' x 13'2"	460/3/100 or 230/3/200	36	36	Coagulants coagulant aids
Kruger Inc.	ACTIFLO Process	conventional-type water treatment process that utilizes microsand as a seed for floc formation	South Site North Site	Nov 8 – Nov 12 Nov 15 – Nov 21	39.3' x 8' x 13.5'	480/3/75	330	360	Coagulants coagulant aids acid (pH control)
Infilco Degremont Inc.	DensaDeg High Rate Clarifier	compact solids contact high rate clarification	North Site	Oct 11 – Nov 10	20' x 8' x 22'	480/3/100	200	140	Coagulants coagulant aids
ROCHEM Environmental Inc.	Ultrafiltration	pressure driven separation process, in which liquid flow occurs from the concentrated solution to the dilute solution across a semi-permeable membrane	South Site	Sep 30 – Nov 30	4'5" x 2'x 1'4"	480/3	2.2	2.0	None
Zenon Environmental Inc.	Microfiltration	'cross-flow with concentrate recycle' solids separation system removing particles greater than 0.1 micron	South Site	Sep 30 – Nov 30	6' x 6' x 6'	480/3	10	10	Coagulants or None
BIOCHEM Technologies Inc.	Dolomitic Lime Fixed Film Bio-Reactor	biological treatment technology utilizing an indigenous sessile bacteria for the uptake of nutrients such as phosphorus and nitrogen.	South Site	Aug 4 – Dec 31	35' x 5' x 3'	120/1/5	10	10	None
MicroMag Corporation	CoMag Process	innovative technology utilizing magnetite seed and high gradient magnetic fields for the separation of floc aggregates.	South Site North Site	Nov 15 – Nov 19 Nov 22 – Nov 26	40' x 8' x 13.5'	480/3/50 KVA 240/3/25	20	20	Coagulants coagulant aids
University of Florida	Bench Scale Coated Media Filtration	patented phase separation technique utilizing metallic hydroxide coated granular filter media	Off Site	July 18, and Sept 10	N/A	N/A	N/A	10 mL/sec to 25 mL/sec	None
Syracuse University / HSA	Bench Scale Glass Sand Filtration	separation technique utilizing 50/50 mix of two washed size fractions (0.6 – 1.18 mm and 0.295 – 0.6 mm) of filter media	South Site	July 20 - Aug 15	mounted on clarifier outside wall	120/1/5	N/A	10 mL/sec	Coagulants coagulant aids
ETUS Inc. / HSA	Jar Testing with Supplied Treatment Chemicals	conventional phase separation technique utilizing vendor supplied treatment chemicals	HSA Lab at South Site	November 18	6' x 2' x 1' (jar test unit)	120/1/5	N/A	N/A	Coagulant aids

Notes: *N/A* *not applicable*
• *unless noted otherwise*
gpm *gallons per minute*